

# Solar Thermal Propulsion Evaluation

**Project Number: 95-13**

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## Purpose

The Solar Thermal Propulsion Evaluation research project was initiated to assess fabrication techniques for a solar thermal absorber/thruster (AT) and evaluate its performance in a propulsion test-bed. The first part of the effort involves fabricating subscale tungsten AT via a vacuum spray process using in-house facilities. The second part entails experimental evaluation of the AT in MSFC's East Test Area. The testing will use a heliostat reflector to direct sunlight onto an 18-ft-diameter concentrator. The concentrator will then focus the light into the AT cavity, which will be located inside a small vacuum chamber to simulate a space environment. Gaseous hydrogen will be used as the propellant.

## Background

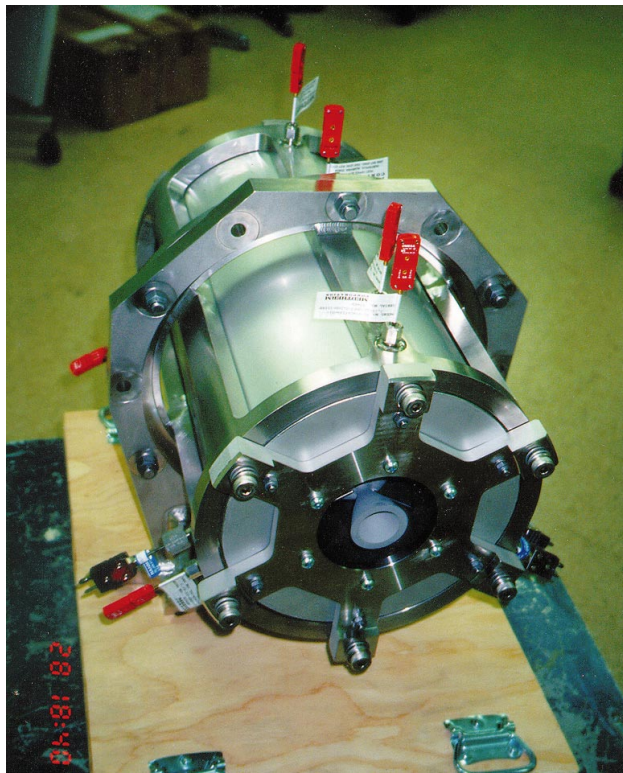
The demand for deployment of small commercial and scientific payloads is expected to rise significantly over the next 20 years. Although chemical, electric, or nuclear propulsion systems could meet this requirement, each of these technologies has several drawbacks that suggest a need for a new concept that bridges gaps in their performance capabilities. A promising alternative, which was conceived in 1956 by Krafft Ehrliche, is solar thermal propulsion (STP). STP effectively bridges the performance gap between chemical and electric propulsion by offering higher Isp's than chemical options and higher thrust-to-weight ratios than electric systems. STP requires only one propellant and combines medium thrust with

moderate propellant efficiency to enable relatively short 30-day trips from low Earth orbit (LEO) to geostationary Earth orbit (GEO).

## Approach

Performance tests of the AT, which is shown installed in its support fixture in figure 7, an STP system will be performed at MSFC's East Test Area. The system consists of a heliostat mirror, concentrator, quartz-windowed vacuum test chamber, the AT, gaseous hydrogen plumbing and propellant tanks, and an experiment control system. The 20 ft × 24 ft heliostat mirror is positioned approximately 200 ft from the concentrator. During a test, the mirror follows the sun via tracking software and redirects solar energy to the 18-ft-diameter concentrator, shown in figure 8. Each of its 144 hexagonal reflective sections focuses incident solar radiation through the test chamber's fused silica window and into the opening of the AT.

The AT will be installed in a 38-in.-diameter × 48-in.-long vacuum chamber, which sits on the stand located to the left of the concentrator in figure 8. The chamber is made of stainless steel and has side ports for viewing and data acquisition. All tests will follow the same procedures and will provide data to enable simultaneous examination of several effects. Several aspects of STP propulsion and material performance will be examined. These include: 1) actual versus ideal specific impulse; 2) exit flow characteristics; 3) solar energy collection efficiency; and 4) materials durability.



**FIGURE 7.—Absorber/thruster installed in test mounting fixture.**

## Accomplishments

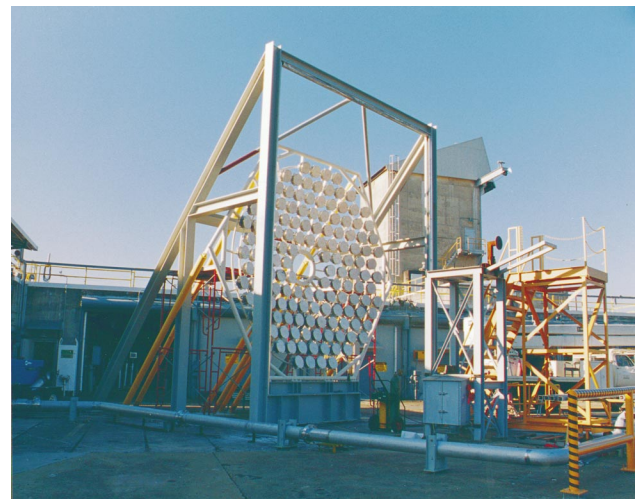
- The phase I STP absorber/thruster made of tungsten has been fabricated and is ready for high temperature testing.
- The heliostat support structure is complete. An acceptable crate of mirror modules has arrived and is awaiting installation.
- The concentrator support structure is complete. All alignment mechanisms have been installed. All hexagonal mirror segments have been fabricated and coated with quartz and are ready for installation. Alignment procedures have been verified.
- The test chamber support structure is complete.
- The test chamber and exhaust system are 98 percent complete.
- A simple test has been performed using a single-mirror module on the heliostat and a few mirror segments on the concentrator to

demonstrate the ability to hold a focal point on target over a one-half-hour duration. The heliostat worked automatically using computer controls. The test was considered a success.

- Design of the drop curtain is complete and fabrication has started.

## Planned Future Work

- Complete STP test facility construction and activation within the next few months.
- Use the phase I STP absorber/thruster as a pathfinder for facility checkouts and initial testing.
- Test phase II STP absorber/thruster and compare results. Possible use of a refractory secondary concentrator on the front of the engine.
- STP test facility available for other STP tests (e.g., shooting star tests, advanced ceramic engine prototype tests, etc.), small electrothermal thrusters (e.g., arcjets, resistojets, microwave thrusters), and subscale simulated nuclear thermal tests.



**FIGURE 8.—Primary concentrator.**

**Funding Summary (\$k)**

All CDDF program funds for this project have been spent or decommitted. Additional funding will be required for touching up facility hardware.

|              | <b>FY95</b> | <b>FY96</b> |
|--------------|-------------|-------------|
|              | 60          | 37          |
| Added funds: |             | 80          |
| Total:       |             | 177         |

**Status of Investigation**

The project was approved on October 1, 1994. We request that the STPE CDDF be continued into FY98 with an estimated projected completion date of June 1998.